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Introduction to the virtual issue on bioeconomy innovation pipelines and supply chain shocks

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Abstract

This introduction presents five articles of the virtual issue on bioeconomy innovation pipelines and supply chain shocks. The presented cases use alternative methodological approaches with their own advantages and disadvantages. The conclusion we can draw is that the specificities of individual case studies make it difficult to generalise and many more cases would be needed to perform a meta-analysis. We encourage agricultural economists to provide further research on detailed cases, which will be particularly important for gaining a better understanding of the potential effects of the EU Green Deal.

Keywords: bioeconomy, supply chains, case studies

JEL classification: Q11, Q11, Q18

Innovation is fundamental to ensuring that societies can produce more with fewer inputs, an important consideration in the current sustainability debate. Growth in population and per capita income is expected to increase the demand for food (particularly meat) and natural resources in general. Without innovation-driven productivity gains, the problems envisioned by Malthus over 200 years ago would be more pronounced in modern societies. Innovations along supply chains are essential to meet the needs of the growing global population while striving to ensure production is as sustainable as possible.

Accelerated by Covid-19 and new biological tools, such as CRISPR-Cas9, advances in biological research create new opportunities for firms to innovate. Innovators seeking investment are adversely affected, however, by various sources of uncertainty. Innovation pipelines, both technical and institutional,

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© The Author(s) 2024. Published by Oxford University Press on behalf of the Foundation for the European Review of Agricultural Economics. All rights reserved. For commercial re-use, please contact reprints@oup.com for reprints and translation rights for reprints. All other permissions can be obtained through our RightsLink service via the Permissions link on the article page on our site–for further information please contact journals.permissions@oup.com. are vital for supply chain development, as supply chains risk stagnation without the continual commercialisation of improved products and changes in market and industrial structure. Recent supply chain shocks, such as those resulting from Covid-19 and dramatic climatic events, have significantly challenged many supply chains. Supply chain disruptions create both business opportunities and uncertainty in markets, the effects of which can ripple through supply chains and ultimately back to decisions about investing in innovation. These disruptions are further affected by national and international policies, which have recently proliferated at the European Union (EU) level with the new policies governing the Green Deal (Kardung *et al.*, 2021) and those on due diligence (Scientific Advisory Board on Agricultural Policy, Food and Consumer Health Protection at the Federal Ministry of Food and Agriculture, 2023).

This virtual special issue features five contributions that assess bioeconomy innovation pipelines, how they may impact the needs of a growing population and their implications for sustainability. These contributions represent case studies investigating different aspects of the bioeconomy.

Bioeconomy innovation pipelines and supply chain shocks are an emerging topic in the literature (Zilberman *et al.*, 2022), but modelling supply chains is no trivial undertaking, as several stages are involved. The model that Muth (1964) introduced laid out some of the fundamentals and related complexities of modelling supply chains, particularly when markets differentiate between product characteristics and new products enter the market (Alston, Norton and Pardey, 1995). Acemoglu and Azar (2020) show that technological change in one sector of an economy stimulates endogenous growth via spillover effects into other parts. The size and direction of the growth effect will depend on the organisation of the supply chains within the economy.

The organisation of supply chains depends on the policy environment in which they are embedded. International and national trade policies and national agricultural and environmental policies are especially relevant to bioeconomy innovation pipelines. They can direct innovations by establishing incentives for investments. As countries tend to have a portfolio of policies, these policies are not always consistent (Wesseler, 2022). In the EU, the Farm-to-Fork strategy aims to reduce the environmental impact of agricultural production by reducing fertiliser and pesticide use but at the same time involves policies that disincentivise the development of alternatives that could achieve this. In the end, this results in an overall increase in food prices in the EU and in fertiliser and pesticide use outside the EU (e.g. Beckman, Ivanic and Jelliffe, 2022).

Economic incentives must be present for the private sector to invest in innovation, and the private sector is essential for translating new ideas into products. The incentives depend on the research and development costs, the costs of market approval and the net benefits from marketing the products (Lee *et al.*, 2023; Nicholson *et al.*, 2023). All three are characterised by an often high level of uncertainty (Tassinari, Boccaletti and Soregaroli, 2023).

While research and development costs and the approval costs of an innovation are often determined by policies at the national level (Lee *et al.*, 2023), the potential benefits also depend on the international market (Mérel, Qin and Sexton, 2023). While countries can determine their national support for research and development as well as the national rules for approval of a new technology, thus enabling a new product's access to the national market, they have less control over access to international markets (Smith, Wesseler and Zilberman, 2021).

The contribution by Mérel, Qin and Sexton (2023) illustrates the welfare impacts of a policy-induced extension of organic production. Organic agriculture has, on average, a lower yield per hectare, which, if applied to a five-fold increase in land allocated to organic rice, wheat, corn and soybeans, could result in a substantial supply chain shock and an increase in food prices, particularly in low-income countries. The overall results show that while consumers in rich countries benefit, consumers in low-income countries pay the price. An increase from about 3 per cent to 15 per cent of organic agriculture in high-income countries increases real food prices in developing countries by up to 6 per cent, with central values of 1.2–2.5 per cent. In their preferred parameterisation, a 3 per cent increase in cropland in rich countries is needed to offset the food price increase in poor countries.

Lee *et al.* (2023) assess the implications of biofuel policies in the United States on greenhouse gas (GHG) emissions, paying attention to the uncertainties underlying the availability of emission data. They combine a physical crop model with details on crop yields and soil carbon sequestration with a partial equilibrium model comparing policy scenarios. Emissions related to different forms of fuel use and refinery processes are derived from a life cycle analysis. The policy scenarios include a 'no policy' scenario and two alternative scenarios reflecting the renewable fuel standard mandates. The welfare costs of abatement are about 233 USD per ton of CO_2 for the corn-ethanol-only scenario and about 150 USD per ton of CO_2 when corn ethanol along with cellulosic ethanol are mandated. The estimated abatement costs of cellulosic biofuels are higher than indicated in the previous studies, with the differences due to considering the indirect effects on fuel and food prices. The authors suggest that these indirect effects can be substantial, illustrating the importance of considering supply chains and their interlinkages.

Recycling sewage sludge is generally seen as contributing importantly to sustainable development by fostering the circular bioeconomy. Tassinari, Boccaletti and Soregaroli (2023) assess the sustainability of recycling sewage sludge to recover nitrogen for fertilisation in agriculture comparing it to the more common landfilling practice. To illustrate the importance of the value chain in relation to sustainability assessment, the authors use a multi-regional input–output (MRIO) model in which including upstream linkages changes the results for sustainability impacts. Overall, accounting for indirect global upstream effects, using sewage sludge for organic fertiliser production generates more jobs and reduces more GHG emissions than landfilling. By contrast, landfilling stimulates the whole economy more, generating higher indirect turnover and reduces energy carrier use more. Considering the value chain using a MRIO model provides additional important information for sustainability assessments that would otherwise be impossible.

Nicholson *et al.* (2023) show that greenhouse-produced leaf lettuce requires substantially higher production costs and hence consumer prices compared to field-based production. Greenhouse production brings several positive environmental effects due to the controlled production environment, and it—and controlled environment agriculture (CEA) more generally—may be an important component of sustainable vegetable production (Wesseler and Zilberman, 2021). That said, Nicholson *et al.* show that this is not yet given for leaf lettuce. They conclude that the rate of technological improvement at the production level must increase further before CEA leaf lettuce supply chains are competitive with open field–based supply chains.

Ahsanuzzaman, Husain and Zilberman (2024) look at the supply chain of Bt eggplants and note that randomised control trials (RCTs), considered the gold standard for assessing interventions at the farm level, have severe limitations in evaluating technology adoption. While RCTs can provide important information, their results are limited by the design of the study. Although the internal validity of RCTs is ensured, the same cannot, in general, be said about their external validity, which substantially limits their explanatory power for technology adoption studies. The results of Ahsanuzzaman, Husain and Zilberman's (2024) study confirm previous findings from an RCT study on the adoption of Bt eggplants. The authors further show that farmers received a higher market price for the genetically modified food product due to the higher quality that consumers observe. Others report a similar finding for other Bt crops, but the higher quality was not directly observable by consumers, as those studies referred to feed and fibre, not food crops. Perhaps most importantly, farmers received a 27-43 per cent markup, with a higher price mark-up at the wholesale than at the retail level, albeit wholesale prices were lower.

All five papers address specific cases within bioeconomy innovation pipelines and supply chain shocks. The cases are quite different and required alternative methodological approaches with their own advantages and disadvantages. The conclusion we can draw is that the specificities of individual case studies make it difficult to generalise and many more cases would be needed to perform a meta-analysis. We encourage agricultural economists to provide further research on detailed cases, which will be particularly important for gaining a better understanding of the potential effects of the EU Green Deal.

Each of the papers in this issue considers a different case study in which advances in production technology or shocks to the supply chain provide insight into the future of agricultural production. Due to the complexities in real-world supply chains we note above, however, more comprehensive analytical methods may be required, such as partial or general equilibrium models or agent-based models, yet those models often do not capture the details that case studies provide. Furthermore, case studies are often ahead of the economic developments in partial and general equilibrium models and can often more easily use current prices and quantities. Case studies are, therefore, an important contribution not only to the cases themselves but also to an early policy analysis.

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